國家科學及技術委員會補助專題研究計畫報告

虛擬現實中的數學問題解決：性別匹配假設（L06）

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本研究具有政策應用參考價值：■否 □是，建議提供機關
（勾選「是」者，請列舉建議可提供施政參考之業務主管機關）
本研究具影響公共利益之重大發現：□否 □是

中 華 民 國 111 年 08 月 14 日

中 文 摘 要 ： 本研究通過數學問題解決來檢驗性別匹配假設（gender-matching hypothesis [GMH]）。最初的GMH預測，同性老師的學生表現更好。延伸到數學問題解決的 GMH 可以通過操作問題代理的性別和解決方案選項的性別來檢查。GMH-agent（GMHa)與最初的 GMH一樣，預測人們在解決性別匹配代理的數學問題時表現更好。GMH選項(GMHo)預測人們會選擇與問題代理人的性別相匹配的數學解決方案選項。由於數學領域的使用，GMHa 和 GMHo 都可能與人們的知識領域進行交互。這兩組假設通過 160 名具有不同背景的個人解決的12 個數學問題進行了檢驗。三因素混合方差分析結果顯示不支持 GMHa。支持 GMHo 是因為參與者選擇了與問題代理人的性別相匹配的解決方案選項。此外，自然科學男性符合 GMHo 預測最多，社會科學男性符合 GMHo 預測最少。這項研究成功地將原始 GMH 的知識擴展到數學問題解決和問題-性別-領域交互作用的面向，並為特別是在教學和問題設計方面，提供教育實務之啟示。

中 文 關 鍵 詞 ： 知識領域； 性別匹配假說； 數學問題解決

英 文 摘 要 ： This study examines the gender-matching hypothesis (GMH) through mathematical problem-solving. The original GMH predicts that students perform better from same-sex teachers. The GMH extending to mathematical problem-solving can be examined by operating the problem agents’ gender and solution options’ gender. The GMH-agent (GMHa), like the original GMH, predicts that people perform better in solving mathematical problems of gender-matching agents. The GMH-option (GMHo) predicts that people choose mathematical solution options that match problem agents’ gender. Both GMHa and GMHo may interact with people’s domains of knowledge due to mathematical domain use. The two sets of hypotheses were examined by 12 mathematical problems solved by 160 individuals with diverse backgrounds. Three-way mixed ANOVA results revealed that the GMHa was not supported. The GMHo was supported because the participants chose solution options matching problem agents’ gender. Besides, natural-science males met the GMHo prediction most and social-science males met the GMHo prediction least. This study successfully extends the knowledge of the original GMH to mathematical problem-solving and problem-gender-domain interaction and offers implications for educational practices, especially in pedagogical and problem designs.

英 文 關 鍵 詞 ： domains of knowledge; gender-matching hypothesis; mathematical problem-solving

Introduction

Solving mathematical problems is both mathematical and cultural behaviors. During problem-solving, people strive to find correct solutions, patterns, and relationships (Burton, 1994), which, however, may automatically trigger their cultural behaviors by responding to the problems' designs, also a cultural artifact. Among diverse cultural behaviors, gendered behaviors are part of personal identity developed from socialization in our cultures (Eccles, 2015; McLean et al., 2020). A typical example is that a school teacher poses a mathematical problem involving agents of a certain gender (e.g., "Susan ate ¼ cup of milk."), where the problem agent contains gendered information ("Susan is a female."), even without being aware of it. Word problems especially with vivid pictures, therefore, can work as a convenient platform for understanding gender-related cultural behaviors while performing mathematical competencies.

From a broad scope, mathematics (or science, technology, engineering, and mathematics [STEM]) as a male domain is a rooted belief in culture. Recent research has indicated that gender differences in STEM achievement can diminish in a gender-equal society (Guiso et al., 2008). The underrepresentation of females in STEM fields is a phenomenon worldwide. Females are much less represented when moving up the academic ladder. For example, EU-28 had 48% female doctoral students and 24% holding a grade-A position; however, in STEM, only 37% female doctoral students and 15% holding a grade-A academic position in 2016 (European Commission, 2019). Taiwan had 25% female STEM higher education graduates in 2019 (Department of Statistics in Taiwan, 2021). The percentages of 15-year-old top mathematics and science performers wishing to become science and engineering professionals when age 30 years are 26% for boys and 15% for girls of OECD countries, but 24% for boys and 9% for girls of Taiwan

(OECD, 2019). These statistics reveal that gender gaps in STEM participation appear to be strong in Taiwan compared with OECD countries.

The unequal gender portions in STEM may be a cause or effect of gender stereotypes, which inevitably may limit the opportunities for females to have role models and then reduce STEM achievements, identities, and careers (Chen et al., 2020). This phenomenon may have already unconsciously influenced cultural artifacts (e.g., mathematical problems) and cultural behaviors (e.g., problem-solving), which is the focus of this study.

Past studies have focused on a related concept called the gender-matching hypothesis (GMH). This study will build its theoretical basis on the original GMH. By linking the GMH to mathematical problem designs and problem-solving processes in relation to gender, this study posits an extended GMH, addresses its underlying rationales, and raises related issues for further investigation. The GMH-agent (GMHa), like the original GMH, predicts that people perform better in solving mathematical problems of gender-matching agents. The GMH-option (GMHo) predicts that people choose mathematical solution options that match problem agents' gender.

Hypotheses

Concretely speaking, this study aims to answer the following two sets of hypotheses.

1. People perform better in solving mathematical problems of gender-matching agents. This performance pattern interacts with gender and domains of knowledge (i.e., examining GMHa).
2. People tend to choose mathematical solution options that match problem agents' gender. This tendency interacts with genders and domains of knowledge (i.e., the GMHo).

Method

Participants and Data Collection

In total, 180 participants filled in the survey. Gender and domains of knowledge were the focused independent factors of this study, which needed large enough sample sizes to generate robust statistical analysis. As such, cases belonging to small sample-size categories were list-wise deleted (i.e., cases without indicating gender identity and cases indicating cross-discipline domains). This procedure resulted in a final sample of 160 participants for later analysis.

The final sample included 57% female and 42% males; 67% from natural science and 33% social sciences and humanities domains; 96% students and 4% the other jobs such as professionals, technicians, and the unemployed; 76% studying for or holding undergraduate degrees, 14% postgraduate degrees, and 10% others.

Measures

Gendered Mathematical Problems

The mathematical problems mainly examined problem-solvers' competencies. The instruction before the start of the test indicated clearly that it was a mathematical test and each problem asked the participants "which will you choose?", not the "problem agents" (Figure 1). The problems examined the mathematical competencies: to classify and recognize classification, to collect data, and to make simple presentations and explanations, based on the "d-I-1" competency for the first-grader in the national mathematics curriculum of Taiwan (Ministry of Education in Taiwan, 2018, p. 9). The competency was chosen because it comprised basic, logical, and broad mathematics abilities suitable for diverse learners.

<Insert Figure 1 here.>

In later data analysis, the mathematically correct solution was coded as 1 = correct and 0 = incorrect. The solution option's gender was coded as 3 = female, 2 = neutral, 1 = male.

Demographics

The participants filled in a survey about their demographics after solving the mathematical problems. Among the diverse demographics (e.g., ages, residential types, and jobs), gender and domain are also the independent variables to examine the hypotheses.

Gender. The participants indicated their gender identity and coded as 2 = female, 1 = male, and missing = 'prefer not to disclose' and else.

Domains (of Knowledge). The participants indicated their identity in a domain of knowledge by answering the question "what is your professional domain?" Domains were coded as:

- 3 = natural sciences (including engineering, medicine, and agriculture)
- 1 = social sciences and humanities (including linguistics, arts, and business)
- Missing = cross-domains, not applicable (high school or before), and others. These were set as missing because they had too few cases to generate robust statistical results.

Data Analysis

Mean scores of mathematical solution correctness and option gender were calculated for each of the three gender types of problem agents (i.e., girl, dog (neutral), and boy). The mathematical solution correctness (1 = correct; 0 = incorrect) and option gender levels (i.e., from 3 = female, 2 = neutral, to 1 = male) served as the dependent variables for the two hypotheses, respectively. The participants' gender and domains of knowledge were the between-subject independent factor variables, while the three gender types of problem agents were the within-subject independent factor variables.

Results

The GMHa, on Mathematical Solution Correctness (Hypothesis 1)

The GMHa (or original GMH) predicts that solving a problem with a matching-gender agent leads to better performance. In addition to gender, individuals' identity in their domains of knowledge plays a role in solution correctness because the problems require mathematical competency to obtain correct solutions.

The results of a three-way mixed ANOVA with post hoc tests fail to support the GMHa. Neither a significant interaction effect occurs between gender and agent or between gender, domain, and agent. Table 1 shows means and standard deviations, Table 2 presents test results.

<Insert Table 1, Table 2, and Figure 2 here.>

The GMHo, on Solution Option Gender (Hypothesis 2)

The GMHo predicts that people tend to choose solution options matching the problem agents' gender when there are more than one mathematically correct solution option (e.g., Figure 1). The results of a three-way mixed ANOVA with post hoc tests on the participants' solution option gender (from 3 = female, 2 = neutral, to 1 = male) generally support the GMHo (Table 1 and Table 2).

The within-subject effect (agent) is significant with a large effect size (GSE = 0.263; Table 2). The result clearly indicates that people have a tendency to match solution options' gender to problem agents' gender in mathematical problem-solving, where mathematical competency is actually the only major concern. As stated in the instructions of the mathematical test, the problem asks for the participant's personal choice ("which [one] would 'you' choose?"), rather than the problem agent's choice (Figure 1).

Discussion

GMHa

Main Results: Fail to Support the GMHa; Girl and Neutral Agents Benefit

The direct result fails to support the GMHa. No interaction effects are found between agent and gender. People do not perform better in solving mathematical problems with matching-gender agents. The result is consistent with most related past studies, failing to support the original GHM or GMHa (Cho, 2012; Hoogerheide et al., 2018; Johnson et al., 2013). This study uses vivid pictures in the problem design (Figure 1), which, however, still fails to support the GMHa, a result unlike the positive result obtained by using VR (Makransky et al., 2019).

Gender by Domain

The other significant results are main effects from gender and domains separately: NS people outperform their SS counterparts. Females outperform males. There is also an interaction effect: NS males outperform SS males. These effects are not directly related to GMHa but can supplement our understanding of how gender and domain intervene in solving the gendered mathematical problems.

NS Outperforms SS, Esp. for Males. The significant main effect of domains (NS > SS) suggests that the mathematical problems are valid in terms of mathematics competency (Leu & Chiu, 2015). Even though the problems used in this study examine mathematics competencies of a grade-1 curriculum, the problem is still valid in distinguishing NS and SS professionals.

Females Outperform Males. The reasons why females outperform males are a meaningful and interesting issue. The first guess is that females have higher mathematical achievement than males. Compared with a recent international student test result, 15-year-old boys outperform girls in mathematics for 5 points on the OECD average, while Taiwan has similar results, but the gender gap is 4 points (OECD, 2019). Therefore, the present females' better performance is hard to attribute to females' higher mathematics competency, especially given the very low degree of difficulty of the problems in this study.

GMHo

Main Results: People Match Option Gender to Agent Gender

This study supports the prediction of the GMHo that people tend to match solution option gender to problem agent gender. The direct evidence is the significant main effect of agent: People choose option gender that matches problem gender (Table 2, Hypothesis 2). Actually or theoretically, there is no need to match solution option gender and problem agent gender because participants are informed that these are "mathematical" problems and that the problems ask to make "your" choices, not the problem agents' choices (Figure 1).

The GMHo appears to be new in the literature of the original GMH and is worthy of notice in the post-modern constructivist era (Roth et al., 2020). The GMHo is also a response to the advocate of including non-routine mathematical problems in mathematics classrooms in order to cultivate higher-order thinking (Chiu, 2009; Chiu & Whitebread, 2011).

Gender by Domain: NS Males Meet the GMHo Prediction Most and SS Males Least

Additional results of this study supplement the above main prediction of the GMHo. In solving mathematical problems with girl agents (neither dog nor boy agents), NS males have a significantly higher tendency to choose gender matching solutions than SS males (Table 2, Hypothesis 2; Figure 2-B). Furthermore, the results for the interaction between gender, domain, and agent reveal that both NS females and males meet the GMHo prediction (i.e., people match option gender to agent gender). SS females partially meet the GMHo main prediction. (Figure 2-C). SS males meet the GMHo main prediction in least because no significant results were found for them.

Conclusion

Contributions and Suggestions for Educational Practices

This study extends the original GMH for pedagogical agents to the dichotomy of GMHa and GMHo for mathematical problem design. The GMHa and GMHo highlight gendered cultural behaviors in response to mathematical problems with different degrees of gender matching contexts in problem agents and solution options, respectively. Mathematical problems with gendered problem agents and multiple gendered correct solutions are a general educational practice though unaware by educators, students, and the public. Solving gendered problems is reasonably a reflection of innate processes manifesting through interaction with personal characteristics such as gender with related beliefs (e.g., stereotype and identity) and domains of knowledge (or fields of study). This study examined the new framework of the GMH by empirical research. Likely contributions to educational research include:

1. Posit the GMHa and GMHo, which appear to be new in literature, extending for problem-solving.
2. Provide further evidence for failing to support the original GMH or the GMHa.

3. Provide strong evidence for supporting the GMHo.

Likely contributions to educational practices include:

1. Problem design: Problem agents may be involved in mathematical problem performance, with a girl or neutral agent benefitting more than boy agents.
2. In the post-modern area, non-routine problems with multiple correct solutions become a daily practice. However, as predicted by the GMHo that people have a tendency to match solution gender to agent gender, especially for NS males. Educators and policymakers need to notice this unconscious problem-solving process, which may lead to more gender-stereotyped design, especially in the STEM field, where males still dominate. Advocating diverse gendered designs is necessary.

Limitations and Suggestions for Future Research

This study limits its problem design to a specific format and gender images. The gendered images may bear cultural bias. The dichotomy of GMHa and GMHo may just be specific to the context of problem design. Whether the dichotomy forms a general or extended GMH is still an issue to resolve by future research.

The survey is administered through the Internet, by which participants can join and quit at their convenient times and places. However, this procedure may reduce the reliability of the survey due to little control in implementing the survey.

References and Bibliography

Ash, A., & Wiggan, G. (2018). Race, multiculturalisms and the role of science in teaching diversity: towards a critical post-modern science pedagogy. *Multicultural Education Review, 10*, 94-120. https://doi.org/10.1080/2005615X.2018.1460894

Baye, A., & Monsieur, C. (2016). Gender differences in variability and extreme scores in an international context. *Large-Scale Assessments in Education, 4*(1), 1-16. https://doi.org/10.1186/s40536-015-0015-x

Burton, L. (1994). *Children learning mathematics: Patterns and relationships*. Simon & Schuster Education.

Carr, M., Steiner, H. H., Kyser, B., & Biddlecomb, B. (2008). A comparison of predictors of early emerging gender differences in mathematics competency. *Learning and Individual Differences*, *18*, 61-75. https://doi.org/10.1016/j.lindif.2007.04.005

Chen, C., Sonnert, G., & Sadler, P. M. (2020). The effect of the first high school science teacher's gender and gender matching on students' science identity in college. *Science Education, 104*, 75-99. https://doi.org/10.1002/sce.21551

Chen, H., Chen, M. F., Chang, T. S., Lee, Y. S., & Chen, H. P. (2010). Gender reality on multi-domains of school-age children in Taiwan: A developmental approach. *Personality and Individual Differences*, *48*, 475-480. https://doi.org/10.1016/j.paid.2009.11.027

Chiu, M.-S. (2009). Approaches to the teaching of creative and non-creative mathematical problems. *International Journal of Science and Mathematics Education, 7*, 55-79. https://doi.org/10.1007/s10763-007-9112-9

Chiu, M.-S. (2017). High school student rationales for studying advanced science: Analysis of their psychological and cultural capitals. *Journal of Advances in Education Research, 2, 171-182.* https://doi.org/10.22606/jaer.2017.23005

Chiu, M.-S., & Whitebread, D. (2011). Taiwanese teachers’ implementation of a new ‘constructivist mathematics curriculum’: How cognitive and affective issues are addressed. *International Journal of Educational Development, 31*, 196-206. https://doi.org/10.1016/j.ijedudev.2010.06.014

Cho, I. (2012). The effect of teacher–student gender matching: Evidence from OECD countries. *Economics of Education Review, 31*(3), 54-67. https://doi.org/10.1016/j.econedurev.2012.02.002

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. Lawrence Erlbaum.

Department of Statistics in Taiwan (2021, April 30). *Gender statistics.* https://depart.moe.edu.tw/ED4500/cp.aspx?n=DCD2BE18CFAF30D0

Eccles, J. S. (2015). Gendered socialization of STEM interests in the family. *International Journal of Gender, Science and Technology, 7*, 116-132.

Ertl, B., Luttenberger, S., & Paechter, M. (2017). The impact of gender stereotypes on the self-concept of female students in STEM subjects with an under-representation of females. *Frontiers in Psychology, 8*, Article 703. https://doi.org/10.3389/fpsyg.2017.00703

European Commission (2019). *She figures 2018*. Available online at: https://ec.europa.eu/info/publications/she-figures-2018_en

Faust, J., Ko, C., Alexander, A., & Greenhawt, S. F. (2017). Parent–child gender matching and child psychological adjustment after divorce. *Journal of Child Custody, 14*, 1-10. https://doi.org/10.1080/15379418.2017.1312658

Gallagher, A. M., De Lisi, R., Holst, P. C., McGillicuddy-De Lisi, A. V., Morely, M., & Cahalan, C. (2000). Gender differences in advanced mathematical problem solving. *Journal of Experimental Child Psychology*, *75,* 165-190. https://doi.org/10.1006/jecp.1999.2532

Gray, H., Lyth, A., McKenna, C., Stothard, S., Tymms, P., & Copping, L. T. (2019). Sex differences in variability across nations in Reading, Mathematics and Science: a meta-analytic extension of Baye & Monseur (2016). *Large-Scale Assessments in Education, 7*(2), 1-29. https://doi.org/10.1186/s40536-019-0070-9

Halpern, D. F., Wai, J., & Saw, A. (2005). A psychobiosocial model: Why females are sometimes greater than and sometimes less than males in math achievement. In J. Kaufman & A. Gallagher (Eds.), *Gender differences in mathematics: An integrative psychological approach* (pp. 48-72). Cambridge University Press. https://doi.org/10.1017/CBO9780511614446.004

Hoogerheide, V., Loyens, S. M., & van Gog, T. (2016). Learning from video modeling examples: Does gender matter?. *Instructional Science*, *44*, 69-86. https://doi.org/10.1007/s11251-015-9360-y

Hoogerheide, V., van Wermeskerken, M., van Nassau, H., & van Gog, T. (2018). Model-observer similarity and task-appropriateness in learning from video modeling examples: Do model and student gender affect test performance, self-efficacy, and perceived competence?. *Computers in Human Behavior*, *89*, 457-464. https://doi.org/10.1016/j.chb.2017.11.012

Hyde, J. S. (2014). Gender similarities and differences. *Annual Review of Psychology, 65,* 373-398. https://doi.org/10.1146/annurev-psych-010213-115057

Johnson, A. M., Ozogul, G., Moreno, R., & Reisslein, M. (2013). Pedagogical agent signaling of multiple visual engineering representations: The case of the young female agent. J*ournal of Engineering Education, 102,* 319-337. https://doi.org/10.1002/jee.20009

Leu, Y.-C. & Chiu, M.-S. (2015). Creative behaviors in mathematics: Relationships with abilities, demographics, affects and gifted behaviors. *Thinking Skills and Creativity, 16*, 40-50. https://doi.org/10.1016/j.tsc.2015.01.001

Makransky, G., & Lilleholt, L. (2018). A structural equation modeling investigation of the emotional value of immersive virtual reality in education. *Educational Technology Research and Development, 66*, 1141-1164. https://doi.org/10.1007/s11423-018-9581-2

Makransky, G., Wismer, P., & Mayer, R. E. (2019). A gender matching effect in learning with pedagogical agents in an immersive virtual reality science simulation. *Journal of Computer Assisted Learning, 35,* 349-358. https://doi.org/10.1111/jcal.12335

McLean, K. C., Boggs, S., Haraldsson, K., Lowe, A., Fordham, C., Byers, S., & Syed, M. (2020). Personal identity development in cultural context: The socialization of master narratives about the gendered life course. *International Journal of Behavioral Development, 44*, 116-126. https://doi.org/10.1177/0165025419854150

Moreno, R., & Flowerday, T. (2006). Students' choice of animated pedagogical agents in science learning: A test of the similarity-attraction hypothesis on gender and ethnicity. *Contemporary Educational Psychology, 31,* 186-207. https://doi.org/10.1016/j.cedpsych.2005.05.002

Moreno, R., Reisslein, M., & Ozogul, G. (2010). Using virtual peers to guide visual attention during learning: A test of the persona hypothesis. *Journal of Media Psychology: Theories, Methods, and Applications, 22*(2), 52-60. https://doi.org/10.1027/1864-1105/a000008

Nuttall, R. L., Casey, M. B., & Pezaris, E. (2005). Spatial ability as a mediator of gender differences on mathematics tests: A biological-environmental framework. In Kaufman, J., & Gallagher, A. (Eds.), *Gender differences in mathematics: An integrative psychological approach* (pp. 121-142). Cambridge University Press. https://doi.org/10.1017/CBO9780511614446.007

OECD (2015). *The ABC of gender equality in education: Aptitude, behavior, confidence*. OECD Publishing. https://doi.org/10.1787/9789264229945-en

OECD (2019). *PISA 2018 results: Combined executive summaries.* https://www.oecd.org/pisa/Combined_Executive_Summaries_PISA_2018.pdf

Ozogul, G., Johnson, A. M., Atkinson, R. K., & Reisslein, M. (2013). Investigating the impact of pedagogical agent gender matching and learner choice on learning outcomes and perceptions. *Computers & Education, 67*, 36-50. https://doi.org/10.1016/j.compedu.2013.02.006

Ozogul, G., Reisslein, M., & Johnson, A. M. (2011). Effects of visual signaling on pre college students' engineering learning performance and attitudes: Peer versus adult pedagogical agents versus arrow signaling. *Proceedings of the 118th annual conference and exposition of the American Society for Engineering Education* (AC 2011-344). https://doi.org/10.18260/1-2--17824

Pargulski, J. R., & Reynolds, M. R. (2017). Sex differences in achievement: Distributions matter. *Personality and Individual Differences*, *104*, 272-278. https://doi.org/10.1016/j.paid.2016.08.016

Roth, S., & Luczak-Roesch, M. (2020). Deconstructing the data life-cycle in digital humanitarianism. *Information, Communication & Society, 23,* 555-571. https://doi.org/10.1080/1369118X.2018.1521457

Sandygulova, A., & O'Hare, G. M. (2018). Age-and gender-based differences in children's interactions with a gender-matching robot. *International Journal of Social Robotics, 10,* 687-700. https://doi.org/10.1007/s12369-018-0472-9

Szumski, G., & Karwowski, M. (2019). Exploring the Pygmalion effect: The role of teacher expectations, academic self-concept, and class context in students' math achievement. *Contemporary Educational Psychology, 59*, 101787. https://doi.org/10.1016/j.cedpsych.2019.101787

Zimmerman, B. J., & Martinez-Pons, M. (1990). Student differences in self-regulated learning: Relating grade, sex, and giftedness to self-efficacy and strategy use. *Journal of Educational Psychology, 82,* 51-59. https://doi.org/10.1037/0022-0663.82.1.51

Figure 1

Problem Samples

A. Which sock would you choose? | B. Which house would you choose?

A girl agent on data. The girl says: ‘I would like to wear yellow socks.’

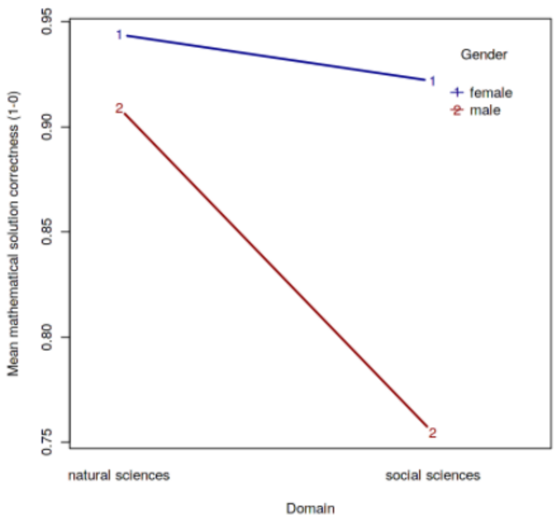
A dog (neutral) agent on geometry. The dog says ‘Which door can my key open?’

Note. The problem samples use images from the open icon source: https://www.irasutoya.com

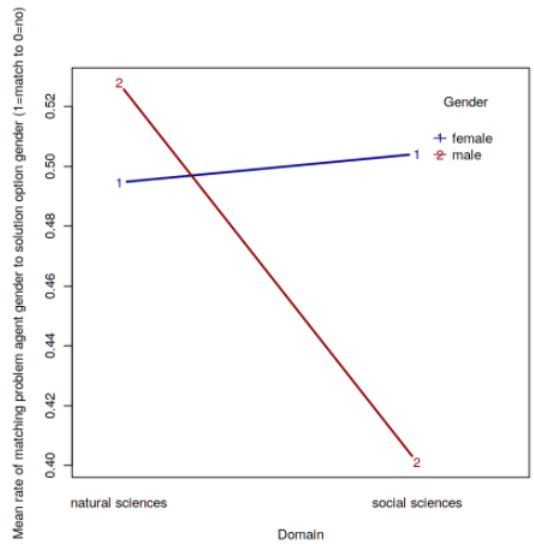
Figure 2

Problem Samples

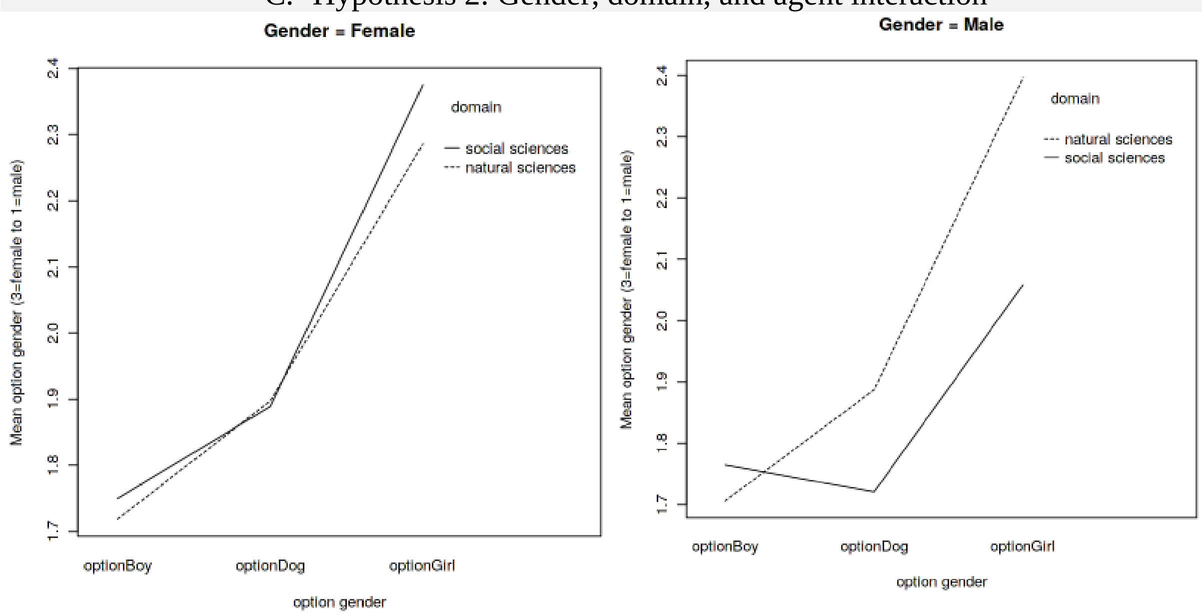
A. Hypothesis 1: Gender and domain interaction for all problems



B. Hypothesis 2: Gender and domain interaction for all problems



C. Hypothesis 2: Gender, domain, and agent interaction



Note. NS = natural sciences; SS = social sciences.

Table 1

Means and Standard Deviations (SD)

Gender	Domain	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Hypothesis 1: Mathematical solution correctness (1=correct; 0 = incorrect) as the outcome									
Participant	problem	all		girl-agent		dog-agent		boy-agent	
All		0.908	0.167	0.919	0.183	0.917	0.185	0.886	0.202
Male		0.870	0.211	0.882	0.234	0.886	0.218	0.842	0.244
Female		0.935	0.120	0.946	0.127	0.940	0.154	0.918	0.158
	SS	0.868	0.222	0.882	0.223	0.877	0.248	0.844	0.256
	NS	0.927	0.129	0.937	0.158	0.937	0.142	0.907	0.167
Male	SS	0.755	0.294	0.750	0.306	0.779	0.317	0.735	0.324
	NS	0.909	0.161	0.926	0.189	0.922	0.162	0.877	0.202
Female	SS	0.922	0.157	0.944	0.135	0.924	0.197	0.896	0.202
	NS	0.944	0.089	0.946	0.124	0.951	0.121	0.933	0.121
Hypothesis 2: Solution option gender as the outcome (3 = female; 2 = neutral; 1 = male)									
All		1.972	0.163	2.317	0.398	1.873	0.306	1.727	0.369
Male		1.960	0.222	2.313	0.417	1.846	0.340	1.721	0.355
Female		1.982	0.186	2.321	0.386	1.894	0.278	1.731	0.380
	SS	1.954	0.205	2.274	0.414	1.835	0.332	1.755	0.365
	NS	1.981	0.201	2.339	0.390	1.893	0.292	1.713	0.371
Male	SS	1.848	0.219	2.059	0.438	1.721	0.363	1.765	0.312
	NS	1.997	0.213	2.397	0.378	1.887	0.325	1.706	0.370
Female	SS	2.005	0.180	2.375	0.366	1.889	0.307	1.750	0.392
	NS	1.967	0.190	2.286	0.397	1.897	0.260	1.719	0.376

Note. NS = natural sciences; SS = social sciences. NS female sample size (n) = 56; NS male n = 51; SS female n = 36; SS male n = 17.

Table 2

Three-Way Mixed ANOVA for Hypothesis 1 and Hypothesis 2

Effect	DFn	DFd	F	p		GES	post hoc test results
Hypothesis 1							
gender	1.000	156.000	12.843	0.000	*	0.058	female > male
domain	1.000	156.000	9.785	0.002	*	0.045	NS > SS
agent	1.900	296.810	3.634	0.030	*	0.006	girl or dog > boy agents
gender:domain	1.000	156.000	5.473	0.021	*	0.026	male: NS > SS (Figure 2-A)
gender:agent	1.900	296.810	0.375	0.677		0.001	
domain:agent	1.900	296.810	0.019	0.977		0.000	
gender:domain:agent	1.900	296.810	0.913	0.398		0.001	
Hypothesis 2							
gender	1.000	156.000	3.304	0.071		0.007	
domain	1.000	156.000	2.534	0.113		0.005	
agent	1.770	275.460	80.738	0.000	*	0.263	girl > dog > boy agents
gender:domain	1.000	156.000	7.078	0.009	*	0.014	male: NS> SS (Figure 2-B)
gender:agent	1.770	275.460	0.774	0.447		0.003	
domain:agent	1.770	275.460	1.945	0.150		0.009	
gender:domain:agent	1.770	275.460	3.205	0.048	*	0.014	NS females or males: girl > dog > boy agents; SS female: girl > dog or boy agents (Figure 2-C)

Note. All the main and post hoc test results are presented in Appendices 1 and 2. NS = natural sciences; SS = social sciences; DFn=degrees of freedom in the numerator ; DFd=degrees of freedom in the denominator; GES = generalized eta squared (η^2) (an indicator for effect size). Small effect size: $0.01 < \eta^2 < 0.06$; medium effect size: $0.06 < \eta^2 < 0.14$; large effect size: $\eta^2 > 0.14$ (Cohen, 1988, p. 283).

* $p < 0.05$

國家科學及技術委員會補助專題研究計畫出席國際學術會議心得報告

日期： 2022年8月12日

計畫編號	NSTC 109-2629-H-004-002		
計畫名稱	虛擬現實中的數學問題解決：性別匹配假設 (L06)		
出國人員姓名	邱美秀	服務機構及職稱	政大教育系教授
會議時間	2022年7月14日至 2022 年7月17日	會議地點	the UCL Institute of Education, London, United Kingdom
會議名稱	(中文)歐洲教育會議 (英文)*The European Conference on Education*		
發表題目	(中文)家長對虛擬現實用於教育目的的經驗和意見 (英文) Parents' experiences and opinions about using virtual reality for educational purposes		

一、參加會議經過

July 14-17: attend keynote speeches, poster and oral presentations, and social networking activities for scholars.
Morning, July 17: chair a session of oral presentations and present my research.

二、與會心得

Birgit Phillips' keynote raised the issue of higher education missions: starting from Bologna focusing on competitiveness and Horizon 2020. Argue from knowledge economy to knowledge democracy from Weird to Wisdom: W=Westernalilzation … vs. i=inclusion. Higher education can focus on community-based participatory research, e-learning for service, and social responsibility.
Other important presentations include:

Keane, M. (Johannesburg Univ., South Africa) establishing a-writing practice remotely: A WhatsApp course for academics.

Zhu, S. Y. (Birmingham City University, UK). Teaching large computer network class with automated marking. 12 weeks of teaching in the UK.

Hayward, B. (Birkbeck, UCL, UK) Resilience embodied in conversations and creativity during a COVID-19 context.

Ma, Y. (Edinburgh Univ.) Global citizenship in Model United Nations: does it work in China? (Griffiths, 1998). Themes in global citizenship: knowledge (international relationship), skills, values, engagement, and responsibility (to display the country's image).

Guzel, F. (Wolverhampton Univ. UK) looking for a needle in the haystack: Autism, motherhood, and resilience in Covid-19.

Chung, E. Y-H, (The education univ. of HK) Outcomes and impact of robot-mediated social skill training to

Autism children

Mohamed, N. (Maldives Natl Univ.) use video in teaching and learning: An action research.

Bungert, K. (Frauehofer FKIE; Univ. Bonn, Germany). Work with Robots teach computer science with educational robots. Grades 5-6 (secondary education) mandatory subjects in school: computer science; LEGO mindstorms EV3 Home APP (based on Scratch); context: parking assistants.

Ripsam, M. (PhD student, Technical Univ. of Munich, Germany). augmented reality for chemistry education, substance-particle concept in teacher trainings.

Wang, Y. (Univ. of East Anglia, UK), decolonization-inspired teaching and learning toolkit. Terminology challenges: culturally sensitive, decolonization; Ethical considerations in the research process: How do we decolonize this research?

Novoa, K. Teachers' perspective on the assessment of the Galician subject "Social and civic values", as an alternative to religion in Spain. This raises an issue about how to assess values, including emotional intelligence. I shared my experience in Taiwan about 'civic and moral education' as a school subject, including psychology, sociology and economics, which make easy ways to assess the knowledge of these domains.

Eadens, D. M. & Eaden, D. W: universal design for learning as pillar of trauma-responsive education. Regulate: first you then others, breathe, convey safety, nurturance, and acceptance; Relate: provide connection, other reassurance. Listen; Reason: provide alternatives. Connecting, correcting, and empowering (Reid, Proctor, and Brooks, 2018). Teachers provide a safe, nurturing, and predictable environment.

Dobrovska: teachers and online teaching in the COVID-19 pandemic. Czech Republic teachers have few experiences of distant online teaching (around 90% no experience) but around 70% perceived distant teaching with both positive and negative aspects.

三、發表論文摘要

Chiu, M.-S. (2022). Parents' experiences and opinions about using virtual reality for educational purposes. Paper presented at *the European Conference on Education (ECE2022)*, the UCL Institute of Education, London, United Kingdom, July 14-17.

This study aims to understand parents' experiences and opinions about using virtual reality (VR), particularly for educational purposes, with the technology acceptance model (TAM) as a theoretical basis. Ten parents (6 females and 4 males; age mean = 40 years) played a VR serious game, solving 12 mathematical problems designed for age-6 children, and filled in an online survey. Then the parents were interviewed about their user experiences of playing VR games before and the just-experienced VR game, followed by their opinions about future use of VR for mathematics and general educational purposes. The interviews were fully recorded and verbatim transcribed. Quantitative and qualitative data analysis methodologies identified the parents' views towards VR use in the past, present, and future. The analysis results show that the parents had very limited experiences (< 2 hours) of playing VR games before and perceive VR as novel innovation and worth pursuing as an industry. The parents perceived the just-experienced VR game as having low degrees of mimicking real-life experiences. While the parents acknowledged the just-experienced mathematical design of the VR games as meeting educational standards, they suggested ways to improve user experiences, such as more interaction, colors to express 3D, and more real-life images. Finally, the parents expressed their readiness to accept a bright future for educational VR in order to fulfil the need for high-quality online learning, especially after the unsatisfied online learning experiences during the COVID-19 pandemic. The findings appear to extend the TAM to a broader scope with a hierarchical structure.

四、建議

Positive psychology can be a basis for national curriculum as that in Israel. Professor Shoshani, A. from Israel reported: Resilience in school in the context of war: Effects of a positive psychology program on school children's mental health. Positive psychology problem to increase the resilience of children experiencing political violence. Course examples: Students teach a topic that interest them. Teachers provide personalized mentoring. Map character strengths. Older children practice mindfulness with younger children. Schools design their own school logos, songs, sculptures in schools by children. Students create positive psychology spaces (e.g., gardens and sculptures) inside or outside schools. Students with these interventions have lower mental problem symptoms. Shoshani (2021). In Journal of Positive Psychology. Prof. Shoshani responded to me and said that her positive psychology program ideas have been accepted and incorporated into Israel's national curriculum for diverse school subjects, including mathematics.

五、攜回資料名稱及內容
Conference guide (ISSN: 2433-7544 PDF; ISSN: 2433-7587 print)

六、其他
Certificate of presentation


64192

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The European Conference on Education (ECE2022)
University College London, London, United Kingdom | July 14–17, 2022
Organised by The International Academic Forum (IAFOR) in partnership with Birkbeck, University of London, the IAFOR Research Centre at the Osaka School of International Public Policy (OSIPP) at Osaka University, and in affiliation with the Institute of Education, University College London (UCL)

Certificate of Presentation

Mei-Shiu Chiu
(National Chengchi University, Taiwan)

has presented the research entitled:

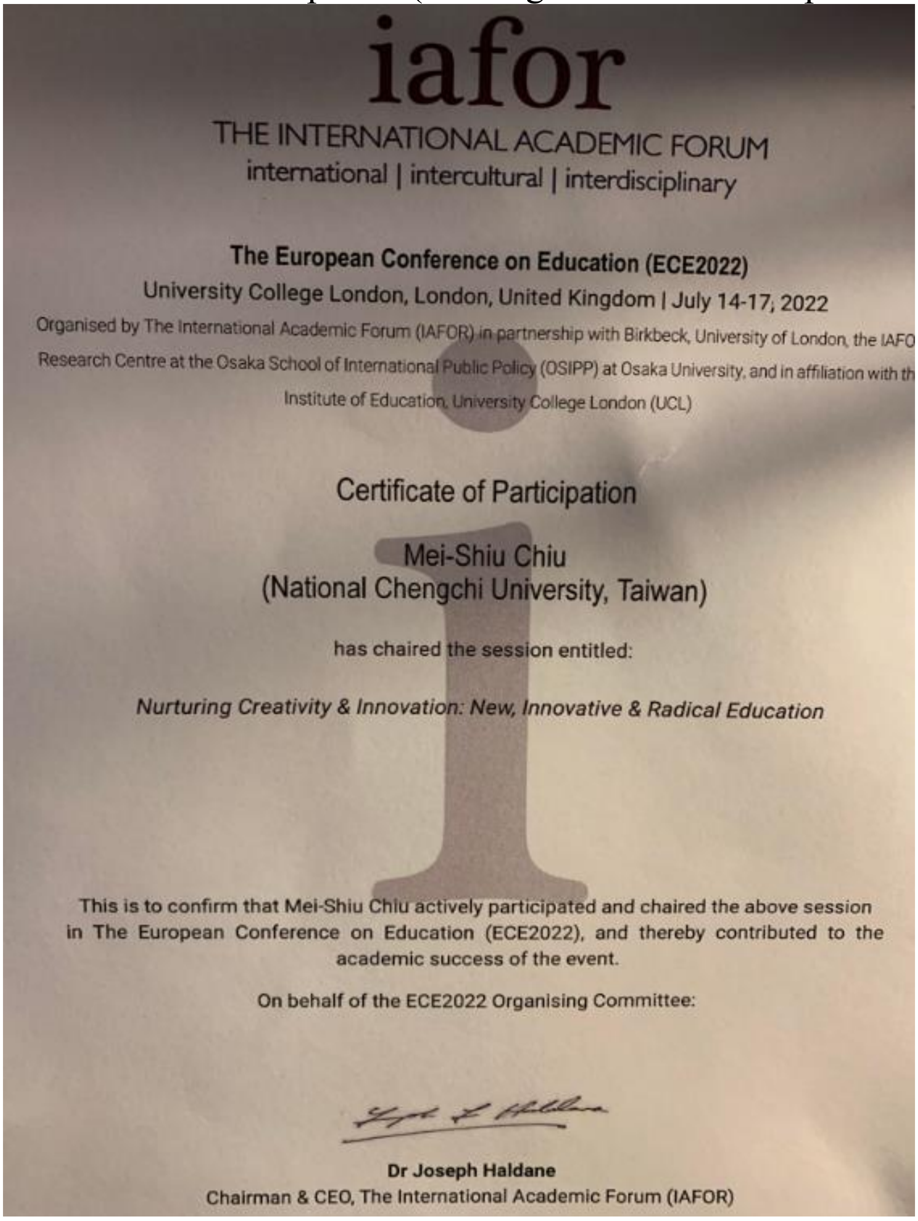
Parents' Experiences and Opinions About Using Virtual Reality for Educational Purposes

This is to confirm that Mei-Shiu Chiu (64192), having presented the above research, actively participated in The European Conference on Education (ECE2022), and thereby contributed to the academic success of the event.

On behalf of the ECE2022 Organising Committee:

Dr Joseph Haldane
Chairman & CEO, The International Academic Forum (IAFOR)

Certificate of Participation (chairing a session of oral presentation)



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Certificate of Participation

Mei-Shiu Chiu
(National Chengchi University, Taiwan)

has chaired the session entitled:

Nurturing Creativity & Innovation: New, Innovative & Radical Education

This is to confirm that Mei-Shiu Chiu actively participated and chaired the above session in The European Conference on Education (ECE2022), and thereby contributed to the academic success of the event.

On behalf of the ECE2022 Organising Committee:

Dr Joseph Haldane
Chairman & CEO, The International Academic Forum (IAFOR)

109年度專題研究計畫成果彙整表

計畫主持人：邱美秀			計畫編號：109-2629-H-004-002-		
計畫名稱：虛擬現實中的數學問題解決：性別匹配假設（L06）					
成果項目			量化	單位	質化（說明：各成果項目請附佐證資料或細項說明，如期刊名稱、年份、卷期、起訖頁數、證號...等）
國內	學術性論文	期刊論文	0	篇	
		研討會論文	1	篇	Chiu, M.-S. (2020). An extended gender-matching hypothesis in mathematical problem-solving. Paper presented at 2020 Asia and Pacific Nation Network Meeting and International Conference on Women in Science and Technology (APNN & IConWiST), 24-25 October 2020, New Taipei City, Taiwan.
		專書	0	本	
		專書論文	0	章	
		技術報告	0	篇	
		其他	0	篇	
國外	學術性論文	期刊論文	2	篇	Chiu, M.-S. (2022). Transcend socioeconomic status constraints to mathematics and science achievement by collaborative problem-solving: The female people-smartness hypothesis. Frontiers in Psychology. (SSCI) Hasumi, T., & Chiu, M.-S. (2022). Online mathematics education as bio-eco-techno process: Bibliometric analysis using co-authorship and bibliographic coupling. Scientometrics. https://doi.org/10.1007/s11192-022-04441-3; online sharing (SSCI; Scopus; SCIE).
		研討會論文	2	篇	Hasumi, T., & Chiu, M.-S. (2021). Online mathematics education: A bibliometric analysis. Global Conference on Education and Research, virtually hosted by University of South Florida, FL, United States, June 9. https://glocer.org/schedule/2/ Chiu, M.-S. (2022). Parents' experiences and opinions about using virtual reality for

					educational purposes. Paper presented at the European Conference on Education (ECE2022), the UCL Institute of Education, London, United Kingdom, July 14-17. https://ece.iafor.org/programme/
		專書	0	本	
		專書論文	0	章	
		技術報告	0	篇	
		其他	0	篇	
參與計畫人力	本國籍	大專生	0	人次	
		碩士生	1		蔡亞靜（2021）。父母如何引導孩子解題？當數學題目中有男、女主角（How do parents guide their children to solve problems? When there are male and female agents in mathematical problems）。國立政治大學幼兒教育研究所碩士論文。
		博士生	0		
		博士級研究人員	0		
		專任人員	0		
	非本國籍	大專生	0		
		碩士生	0		
		博士生	0		
		博士級研究人員	0		
		專任人員	0		
其他成果 （無法以量化表達之成果如辦理學術活動、獲得獎項、重要國際合作、研究成果國際影響力及其他協助產業技術發展之具體效益事項等，請以文字敘述填列。）					